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MODELLING OF HEAT TREATMENT OF PLATES FROM ALUMINUM ALLOYS USING ESI GROUP SOLUTION FOR HEAT TREATMENT

ABSTRACT

To produce competitive high quality product with reducing manufacturing cost more and more companies make a choice of using numerical simulations as the first manufacturing step. Virtual manufacturing solution from ESI Group helps users to find the best way of organization manufacturing process, to avoid mistakes in real life, evaluated them during simulation processes.

Keywords: numerical simulations, SYSWELD, aluminum alloys, virtual manufacturing solution, organization manufacturing process

Numerical simulations are the necessary part of modern and progressive manufacturing. It helps on all stages of manufacturing starting from design creation and finishing with maintenance of produced final product.

Heat treatment and welding are indispensable steps in the manufacture of a big amount of products. Therefore, success or failure of heat treatment not only affects manufacturing costs but also determines product quality and reliability. With regard to simulation based design and manufacturing, it is desirable to calculate the effects of heat treatment and welding in advance and to optimize them by varying materials and workpiece shape. Once the part shape is designed, it is of utmost importance to make sure that the heat treatment, or welding, process is correct and that the process window is safe against process parameter variation. With the aid of the finite element analysis software SYSWELD, such calculations can be carried out for all generally applied heat treatment and welding processes, taking all significant physical effects into account.

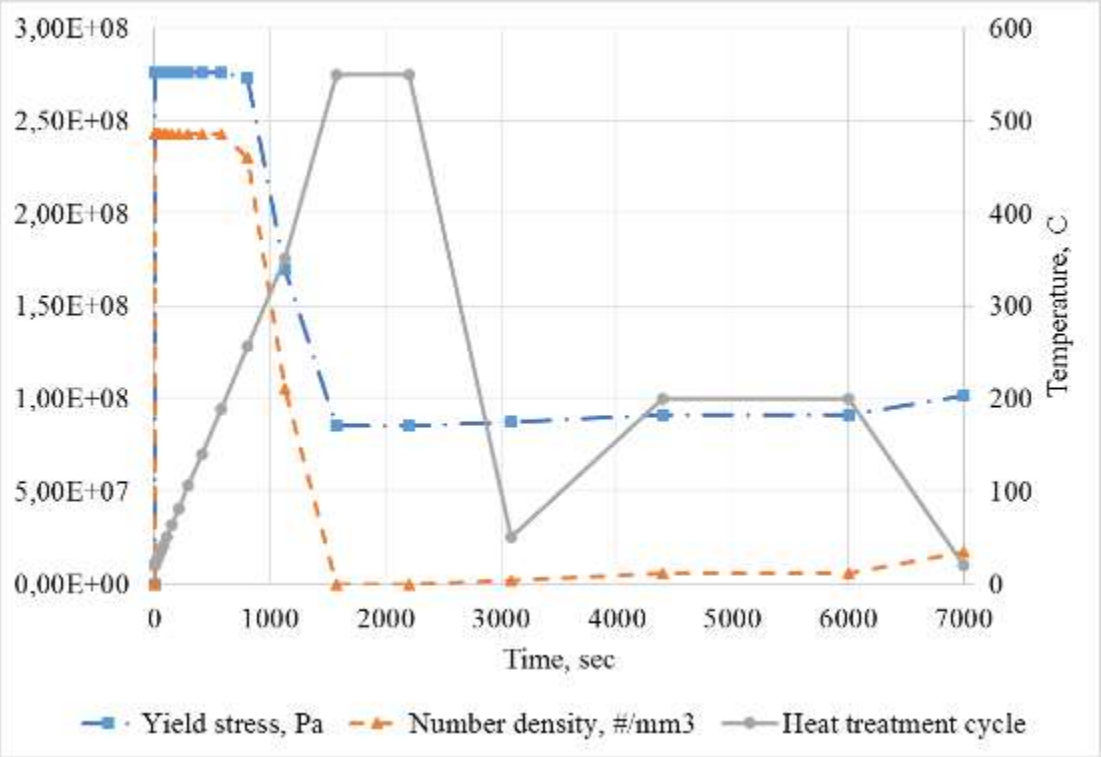
6XXX series aluminum alloys are extensively used for their good combination of specific strength, formability and damage tolerance. These outstanding mechanical properties are obtained through a specific heat treatment optimized to get the highest density of hardening precipitates. However, welding and of age hardening alloys leads to drastic change in the precipitation state within the molten zone and the Heat Affected Zone (HAZ) as precipitates may grow, shrink, dissolve and/or coarsen. These modifications degrade the mechanical properties and therefore the global product performance.

The classical way to better understand the relationship between microstructure and resulting mechanical properties is based on microstructural

and mechanical experimental characterization. However, for some processes, microstructural gradients make the microstructural and mechanical characterization very difficult, sometime impossible. A coupled numerical approach able to predict both the precipitation evolution and the resulting mechanical properties is an attractive way to overcome this difficulty.

For this purpose in SYSWELD was implemented a sharable library of the Software "PreciSo", which has been developed at INSA of Lyon (in the laboratory MATEIS). It enables, based on the thermal history, simulate of the germination, the growth and the dissolution of the precipitates and the effect of this results on the mechanical properties such as the yield stress and the hardening.

There was used 6061 alloy with a starting state T6 to simulate influence of heat treatment regime (pic. 1) on the precipitation size distribution and the yield strength in the plate.



Pic. 1. Dependence of yield stress and precipitate number density from heat treatment

The precipitation state (in terms of volume fraction and precipitate size distribution) is modeled with classical nucleation and growth theories for needle shaped precipitates. The precipitation size distribution is then used as an entry parameter of a micro-mechanical model for the yield strength of the alloy.

It is seen, that during quenching amount of precipitates and yield stress reduce and became growth during aging. This new approach in SYSWELD allows to simulate heat treatment and welding of Al alloys hardenable by heat treatment taking into account physics of process.

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